The J-Curve Phenomenon: Myth or Reality?

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Abstract: This study examines the J-curve phenomenon for the U.S. agricultural trade and compares the effect on agricultural trade relative to the U.S. non-agricultural trade. For this purpose, the autoregressive distributed lag (ARDL) model is adopted to estimate bilateral trade data between the U.S. and her three major trading partners ─ Japan, Canada and Mexico. We find little evidence of the J-curve for the U.S. agricultural trade with Japan, Canada and Mexico. For the non-agricultural trade, on the other hand, the behavior of the U.S. trade with industrialized economies such as Japan and Canada follows the J-curve, but not with developing economies such as Mexico.

Key Words: Agricultural trade, autoregressive distributed lag model, J-curve effect, non-agricultural trade

Introduction

The J-curve theory is the traditional wisdom of economics to analyze the dynamic effect of exchange rate changes on trade balance. Assuming that the Marshall-Lerner (ML) condition ― the sum of domestic and foreign price elasticities of demand (in absolute value) is greater than one ― holds, it is possible that, following a depreciation, an initial decline in the trade balance occurs before showing an improvement. The response of trade balance over time resembles a tilted J shape. The J-curve phenomenon is attributed to a lagged adjustment of quantities to changes in relative prices (Magee 1973, Junz and Rhomberg 1973). For example, if there is a depreciation of the domestic currency, then the increased competitiveness in the domestic prices leads to exporting more and importing less, thereby improving the trade balance, which is known as the volume effect. At the same time, the depreciation increases the import unit value and results in a deterioration of trade balance, which is referred to as the value (price) effect. The value effect prevails in the short-run, whereas the volume effect dominates in the long-run, which causes the time path of the trade balance depicted by the J-curve phenomenon.

In the literature on international economics, many studies have been conducted to examine the J-curve hypothesis in U.S. and other countries. The evidence that emerged from the literature is rather mixed. Some studies have found the evidence of the J-curve phenomenon (for example, Bahmani-Oskooee 1985, Moffett 1989), while others have found no evidence of it (for example, Rose and Yellen 1989, Rose 1991). These studies generally can be classified into two groups. With aggregate data, the first group uses a two-country (i.e., home and foreign) model to analyze the J-curve phenomenon (for example, Felmingham 1988, Guptar-Kapoor and Ramakrishnan 1999). By criticizing that the findings of no J-curve effect obtained by the first group may be due to aggregation bias of data, the second group uses bilateral trade data between a country and its major trading partners to test the J-curve hypothesis (for example, Marwah and Klein 1996, Bahmani-Oskooee and Brooks 1999).

In the agricultural trade literature, on the other hand, most studies have mainly concentrated on the effect of changes in exchange rate on agricultural export volume and/or prices (Gardner 1981, Bessler and Babula 1987, Bradshaw and Orden 1990, Orden 1999). Limited efforts have been made to investigate the impact of exchange rate fluctuations on the agricultural trade balance. To our knowledge, Carter and Pick (1989) is the only published study that has been done to test the J-curve hypothesis for the U.S. agricultural trade balance. Based on the short-run dynamic model, they find partial evidence supporting for the J-curve; that is, the first section of the J-curve exists and the depreciation of the U.S. dollar leads to a deterioration of the trade balance.

Given the shrinking U.S. agricultural trade surplus and the decrease in the value of the U.S. dollar during the period of 2002-2004, it is timely and important to understand the effect of exchange rate changes on the trade balance. Specifically, during the 2002-2004, the value of the U.S. dollar decreased by approximately 17% and 10% against the Canadian dollar and the yen, respectively. In addition, the U.S. dollar declined by approximately 20% against the euro for the three years. Despite the decrease in the value of the U.S. dollar, the U.S. agricultural trade surplus deteriorated during the same period. The trade balance dropped by approximately 34%, from $11.2 billion in 2002 to $7 billion in 2004. Moreover, the U.S. Department of Agriculture (USDA) recently predicted that if this trend continues, the U.S. will see a deficit in its agricultural trade by 2010.

The objective of this study is to examine the dynamic effect of exchange rate changes on the U.S. agricultural trade balance (i.e., J-curve effect) and to compare the impact on agricultural trade relative to U.S. non-agricultural trade. For this purpose, we use bilateral trade flow data between U.S. and her three largest trading partners ─ Canada, Mexico and Japan, and separate the total trade data into trade in agricultural and non-agricultural products. These three countries consist of approximately 40% of U.S. agricultural trade (Table 1). In addition, it is important to include the long-run dynamics in a model since the short-run effects of exchange rate changes could be different from the long-run effects (Bahmani-Oskooee and Ratha 2004). In this paper, therefore, we employ an autoregressive distributed lag (ARDL) model developed by Pesaran et al. (2001), which allows us to capture both the short-run and long-run effects of exchange rate changes on the trade balance.

The remainder of this paper is organized as follows. First, we briefly introduce the theoretical framework for the J-curve effect. Next, we describe the empirical models used for our analysis. Then, we present data and empirical procedure, followed with a presentation of our empirical results. Finally, we make some concluding remarks.

Theoretical Framework

The trade balance is defined as the difference between value of exports and value of imports as follows:

$$TB = P_x X - eP_x^* M \tag{1}$$

where TB is the trade balance in domestic currency; P_x is the domestic export price in domestic currency; P_x^* is the foreign export price in foreign currency; X (M) is the quantity of exports (imports); and e is the exchange rate expressed as domestic currency per foreign currency.

To show the possible effect of exchange rate changes on trade balance, we then differentiate equation (1) with respect to exchange rate (e) and put the results in elasticity form as follows:

$$\frac{dTB}{de} = P_x X\left[\frac{(1+\varepsilon)\eta^*}{(\varepsilon+\eta)}\right] - eP_x^* M\left[\frac{(1-\eta)\varepsilon^*}{(\varepsilon^*+\eta)}\right] \tag{2}$$

where η (η^*) denotes the absolute value of the domestic (foreign) price elasticity of demand; and ε (ε^*) denotes the absolute value of the domestic (foreign) price elasticity of supply. Equation (2) is known as the Bickerdike-Robinson-Metzler (BRM) condition. If trade is in balance (TB=0) in an initial equilibrium, and both supply elasticities are infinite ($\varepsilon \to \infty$ and $\varepsilon^* \to \infty$), then equation (2) reduces to the well-known Marshall-Lerner (ML) condition; a country's devaluation can improve a trade balance when the sum of domestic and foreign price elasticities of demand (in absolute value) exceeds one ($\eta + \eta^* > 1$).

The J-curve theory shows that the short-run adjustment process of trade balance after a devaluation can be divided into three parts: the currency-contract period, the pass-through period, and the quantity-adjustment period (Magee 1973). The current-contract period is defined as the brief period immediately following a devaluation in which contracts negotiated before the change fall due. For example, consider the case in which domestic export contracts are denominated in domestic currency and domestic import contracts denominated in foreign currency. In this case, a devaluation of domestic currency increases exchange rate (e) in equation (1) and immediately deteriorates trade balance in the currency-contract period before any price and volume changes.

The pass-through period is defined as the period after a devaluation in which prices can change but quantities of exports and imports remain unchanged. This is also known as the value (price) effect. The pass-through effect depends on the scale of demand and supply elasticities of exports and imports. For example, consider the situation in which both domestic and foreign demand for imports are inelastic in the short-run. Under this circumstance, equation (2) can be reduced to as follows:

$$\frac{dTB}{de} = P_x X - eP_x^* M \tag{3}$$

As a consequence of a devaluation, the import price measured in domestic currency (eP_x^*) increases but the demand stays the same, thereby resulting in an increase of value of imports (i.e., full pass-through). On the other hand, the export price in foreign currency decreases by the same proportion of the exchange rate variation (full pass-through) and the export price in domestic currency (P_x) remain unchanged. This contributes to a deterioration of trade balance before any trade volume changes. To combine both the currency-contract and the pass-through effects, therefore, the trade balance in domestic currency is expected to decrease following a J-curve pattern.

The quantity-adjustment period is defined as the period in which quantities start to adjust in response to changes in prices. This is also known as the volume effect. Under this circumstance, as both export and import elasticities increase, domestic volume of exports (imports) increases (decreases) in response to the price drop (increase) in foreign (domestic) currency. As a result, the trade balance eventually improves as long as the ML condition is satisfied.

It should be emphasized that in the currency-contract and pass-through periods, there is no logical necessity for a country's trade balance to show the initial portion of the J-curve — the deterioration of trade balance in domestic currency (Magee 1973). The necessary conditions for the initial deficit in trade balance are that: (1) domestic export contracts are denominated in domestic currency and import contracts denominated in foreign currency in the currency-contract period and (2) domestic and foreign price elasticities of demand is inelastic and yield full pass-through in the pass-through period.[1] As such, a devaluation of domestic currency may lead trade balance to improve initially or remain constant according to circumstances. For example, when export contracts are denominated in foreign currency and import contracts denominated in domestic currency, the value of exports in domestic currency increases by the same percentage of the devaluation but the value of imports in domestic currency remains unchanged, thereby improving trade balance in the currency-contract period. Or, if both domestic and foreign supply of exports are inelastic in the short-run, export prices in foreign currency increases by the same proportion of the exchange rate variation but import prices in domestic currency remains unchanged (i.e., no pass-through), thereby an increase of trade balance in the pass-through period.

Empirical Models

We employ a reduced form of trade balance model developed by Rose and Yellen (R&Y) (1989) to analyze the long-run effects of changes in exchange rate on the trade balance. The R&Y use a bilateral trade model in which trade balance is expressed as a function of real exchange rate and the domestic and foreign income. For our empirical analysis, the R&Y model is specified as follows:

(4) $$TB_{it} = \alpha + \beta_1 Y_{US,t} + \beta_2 Y_{i,t} + \beta_3 ER_{i,t} + \varepsilon_t$$

where TB_{it} is the U.S. trade balance with its trading partner i, i = Canada, Japan and Mexico; $Y_{US,t}$ is the real U.S. income; $Y_{i,t}$ is the real income of trading partner i; $ER_{i,t}$ is the bilateral real exchange rate between the U.S. and the currency of trading partner i; and ε_t is the error term.

Note that the U.S. trade balance used is defined as the ratio of U.S. imports from country i to U.S. exports to country i (expressed as trade deficit). One of the major reasons for using the ratio is that it is not sensitive to the units of measurement and can be interpreted as real trade balance. In addition, the ratio can narrow the range of the variable to make it less susceptible to outlying or extreme observations (Wooldridge 2000). Finally, the ratio can be transformed into a logarithmic form without worrying the possible negative values. Economic theory suggests that if a rise in U.S. (trading partner) income increases U.S. imports (exports), the coefficient of U.S. (trading partner) income is expected to be positive (negative). However, if an increase in U.S. (trading partner) income is a result of a rise in production of import-substitute commodities, U.S. imports (exports) may decline as U.S. (trading partner) income increases. In this case, the expected coefficient of U.S. (trading partner) income is negative (positive). Finally, the coefficient of exchange rate is expected to be positive if the depreciation of the U.S. dollar increases exports and decreases imports.

To capture the dynamic effect from the depreciation on the trade balance or the J-curve effect, it is necessary to incorporate the short-run dynamics into the long-run model (equation (4)). To that end, we adopt an autoregressive distributed lag (ARDL) model developed by Pesaran et al. (2001) in which equation (4) is included as an error-correction regressor (lagged one period). Let $z_t = [TB_{i,t}, Y_{US,t}, Y_{i,t}, ER_{i,t}] = [TB_{i,t}, x_t]$. Then the ARDL model of interest can be written as follows:

$$\text{(5)} \qquad \Delta TB_{i,t} = a_0 + a_1 t + b_1 TB_{t-1} + b_2 x_{t-1} + \sum_{i=1}^{p-1} \Psi_i \Delta z_{t-i} + \delta \Delta x_t + \varepsilon_t$$

where Δ is the difference operator; p is lag order; and ε_t is assumed serially uncorrelated. The traditional cointegration tests such as Engle and Granger (1987) and Johansen (1995) concentrate on cases in which the underlying variables are integrated of order one or $I(1)$. These procedures inevitably involve a certain degree of pre-testing and introduce a further degree of uncertainty into the analysis of relationships in levels among variables (Pesaran et al. 2001). To overcome the shortcomings, Pesaran et al. (2001) develop an alternative approach to testing for the existence of cointegration (levels) relationships without classifying variables as purely $I(0)$, purely $I(1)$ or mutually cointegrated. As such, unlike a standard vector autoregressive (VAR) model, the ARDL model does not require unit root tests.

Data and Econometric Procedure

Data

Quarterly data are collected for the period of 1989-2004 (1989:1-2004:4). The total values of exports and imports for agricultural and non-agricultural products between the U.S. and her three trading partners — Canada, Mexico and Japan, are obtained from the ITC Trade Dataweb in the U.S. International Trade Commission (USITC). The U.S. trade balance is then defined as the ratio of imports to exports for agricultural and non-agricultural products with the three trading partners. The real gross domestic production (GDP) is used as a proxy for the real income and is taken from the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). The GDP deflator obtained from the IFS is used to derive real GDP (2000=100). The bilateral real exchange rate is also obtained from the IFS. Since the exchange rate is expressed as the number of trading partner's currency per unit of the U.S. dollar, a decline in exchange rate indicates a real depreciation of the U.S. dollar. Finally, all variables are in natural logarithms.

Econometric Procedure

To estimate equation (5), we first need to determine the lag length (p) included in the ARDL model. Pesaran et al. (2001) note: "It is crucial to balance between choosing p sufficiently large to mitigate the residual serial correlation problems and sufficiently small to avoid over-parameterized, particularly in view of the limited time-series data which are available" (p. 308). We thus use the Akaike Information Criterion (AIC) and Lagrange multiplier (LM) statistics for testing the hypothesis of no serial correlation against orders 1 and 3, respectively (Table 2).[2] Note that because of space limitations as well as similar testing procedures, we mainly summarize our testing procedures for the trade between the U.S. and Canada before presenting our empirical findings.

The AIC indicates that lag 5 ($p_{aic} = 5$) is the appropriate lag length for the agricultural trade between the U.S. and Canada. However, the LM statistics show that the null of no serial correlation can be rejected at $p_{aic} = 5$ and even $p_{aic} = 4$, which gives the second highest AIC statistic. Since serially uncorrelated errors are the crucial assumption for the validity of the test, we select lag 2 ($p = 2$), which provides the third highest AIC statistic as well as the acceptance of no serial correlation. For non-agricultural trade, on the other hand, both the AIC and LM test consistently indicate $p = 2$ (Table 2).

With the selected lag length(s), we then test the existence of a level relationship (cointegration) among variables (TB_{t-1}, x_{t-1}). For this purpose, the null hypothesis of no level relationship, namely ($b_1 = b_2 = 0$) in equation (5) is tested, irrespective of whether the regressors are purely $I(0)$, purely $I(1)$ or mutually cointegrated. This can be done using an F -test with two sets of asymptotic critical values tabulated by Pesaran et al. (2001) in which all the regressors are assumed to be purely $I(0)$ or purely $I(1)$.[3] If the computed F-statistic lies outside the upper level of the critical bounds, the null can be rejected, indicating that the variables are cointegrated. On the other hand, if the F-statistic falls below the lower level of the critical bounds, the null cannot be rejected, supporting lack of cointegration. For example, with $p = 2$ for the agricultural trade, the F-statistic is 4.73, which lies outside the upper level of the 5% critical bounds (Table 2).[4] As a result, the null hypothesis that there exists no cointegrated trade balance equation can be rejected, irrespective of whether the regressors are purely $I(0)$, purely $I(1)$ or mutually cointegrated. In addition, with $p = 2$ for the non-agricultural trade, the hypothesis of no cointegrated trade balance equation is conclusively rejected at the 5% significance level.[5] Overall, our results support the existence of cointegrated trade balance equations when using $p = 2$ for the agricultural and non-agricultural trade between the U.S. and Canada.

Similarly, the F-statistics are 6.71 ($p = 3$) for the non-agricultural trade with Japan and 9.63 ($p = 2$) for the agricultural trade with Mexico, which lie above the 5% upper bound. However, the test results for the agricultural trade with Japan and the non-agricultural trade with Mexico are 2.87 ($p = 3$) and 2.95 ($p = 4$), respectively, which fall within the 10% bound. If the F-statistic lies between the two bounds, the inference is inconclusive. In these cases, the error-correction terms in the ARDL model are used to determine the existence of cointegrated trade balance equations. Hence, if a negative and significant lagged error-correction term is obtained, the variables are said to be cointegrated.

Empirical Results

As discussed earlier, it is necessary to combine the short-run dynamics of the trade balance adjustments with estimates of the long-run cointegration relationships in order to capture the J-curve effect. To that end, we first estimate the long-run trade balance model in equation (4) to identify the cointegration relationship among variables (Table 3). The results show that the U.S. trade balance has a positive long-run relationship with real exchange rates for the agricultural and non-agricultural trade with the three countries. This suggests that the depreciation of the U.S. dollar indeed improves the trade balance in the long-run. The U.S. trade balance with Japan has a positive long-run relationship with real domestic income and a negative relationship with real foreign income for the agricultural and non-agricultural trade. This indicates that a rise in real U.S. (foreign) income increases domestic (foreign) demand for foreign imports (domestic exports), thereby deteriorating (increasing) the trade balance. On the other hand, the U.S. trade balance with Canada has a negative long-run relationship with domestic income and a positive relationship with foreign income for both cases. This suggests that an increase of real domestic (foreign) income decreases domestic (foreign) demand for foreign imports (domestic exports), thereby improving (deteriorating) the trade balance. In other words, since imports are defined as the difference between domestic consumption and production, an increase in domestic income could increase the domestic production of import-substitute commodities faster than a rise in domestic consumption, which thus leads to the reduction of domestic imports (Magee 1973, Bahmani-Oskooee 1985). Finally, the U.S. trade balance with Mexico has a positive (negative) relationship with domestic income and a negative (positive) relationship with foreign income for the non-agricultural (agricultural) trade. However, most cases are not statistically significant.

We then adopt the ARDL model to estimate equation (5).[6] For this purpose, the estimated residuals from equation (4) are used as error-correction terms in equation (5) (Table 4). The sign of the coefficient of the exchange rate determines the existence of the J-curve effect.

That is, an initially negative sign followed by a positive one on the lag coefficients would be consistent with the J-curve phenomenon. The results of the agricultural trade show that all the coefficients of the current and lagged exchange rate (except for the current lag of Mexico) are not statistically significant. Thus, the findings indicate that there is no J-curve effect for the U.S. agricultural trade with Japan, Canada and Mexico. On the other hand, it appears that the J-curve effect exists for the U.S. non-agricultural trade with Japan and Canada. The signs of the coefficients of current and one-period lagged exchange rate are negative and statistically significant at the 5% level. These negative signs are followed by positive signs, which is statistically significant at the 10% level. This implies that after the devaluation of the U.S. dollar, it takes at least two quarters for the non-agricultural trade balance to deteriorate before it starts improving. In contrast, the results show that there is no J-curve effect for the U.S. non-agricultural trade with Mexico. The signs of the coefficients of current and two-period lagged exchange rate are positive, followed by negative signs, indicating the reversed J-curve phenomenon. However, most coefficients are not statistically significant. Notice that all the error-correction terms in all cases are negative and statistically significant at least at the 10% level. The findings thus justify the ARDL modeling of the U.S. agricultural trade with Japan and the U.S. non-agricultural trade with Mexico in which the results of the F-statistics are inconclusive.

Concluding Remarks

This study examines whether there is the J-curve effect for the U.S. agricultural trade and compares the effect on agricultural trade relative to the U.S. non-agricultural trade. To that end, the ARDL model is used to estimate bilateral trade data involving trade flows between the U.S. and her three major trading partners such as Canada, Japan and Mexico for 1989:1-2004:4.

We find little evidence that there is a J-curve effect for the U.S. agricultural trade with Canada, Japan and Mexico. One possible explanation for this is that the necessary condition for the J-curve in the currency-contract period may not hold for the U.S. agricultural trade; U.S. export contracts should be denominated in dollars and U.S. imports contracts denominated in foreign currency. However, such an explanation may not be conclusive in view of the fact that the currency-contract analysis deals with very brief period immediately following a devaluation and because the currency in which prices are quoted presumably would be changed to avoid an exchange rate loss (Magee 1973). Moreover, it is not likely to find qualitative or survey evidence on the currency denomination of U.S. (agricultural) trade. Thus, the most likely explanation for the finding is that U.S. agricultural trade may not meet the necessary condition for the pass-through effect; U.S. and foreign price elasticities of demand are inelastic. In fact, in the short-run, supply of U.S. agricultural exports is generally inelastic, while demand is relatively elastic due to the availability of other major exporters such as Australia and the EU. Under this circumstance, as a consequence of a depreciation, the dollar price of U.S. exports increases but the dollar price of U.S. imports remains unchanged (i.e., no pass-through). As a result, the U.S. agricultural trade does not show the initial deterioration of the trade balance.

We also find that for the non-agricultural trade, the behavior of the U.S. trade with Canada and Japan follows the J-curve, but not with Mexico. U.S. non-agricultural trade with industrialized economies such as Canada and Japan has been mainly characterized as intra-industry trade based on imperfect competition and product differentiation (e.g., quality, location, size, and so on). In this case, demand is generally inelastic since products are greatly differentiated and consumers do not tend to switch easily between differentiated products in response to short-term changes in prices. Hence, the dollar price of U.S. exports remains unchanged and the dollar price of U.S. imports rises by almost the full amount of the devaluation (i.e., full pass-through), thereby contributing to the initial decline in the trade balance. On the other hand, U.S. trade with developing economies such as Mexico has been mostly inter-industry trade based on the principle of comparative advantage (i.e., Heckscher-Ohlin theorem) and perfect competition. In this case, demand is relatively elastic because of the availability of supplies from other developing countries. Hence, the dollar price of U.S. imports would not be driven by the full amount of the depreciation (i.e., no pass-through) and the initial deterioration of the trade balance does not occur.

Finally, our findings suggest that the shrinking agricultural trade surplus for the recent periods cannot be explained by the J-curve effect. As such, the effects of other factors on the trade balance deterioration should be considered in future research.

Footnotes

[1] When export and import contracts are denominated in foreign currency, both export and import prices in foreign currency remains unchanged. In this case, trade balance in domestic currency increases or decreases, or stay constant, depending on whether the initial situation is a surplus, deficit, or balance. For this reason, it is also said that a necessary condition for the J-curve in the currency-contract period only requires domestic import contracts denominated in foreign currency (Magee 1973).

[2] To ensure comparability of results for different choices of lag length, all estimators use the same sample period, 1990q3-2004q4 (T=60), with the first seven observations reserved for the construction of lagged variables.

[3] This is called a bounds testing procedure since the two sets of critical values provide critical value bounds for all possibilities of the regressors into purely $I(0)$, purely $I(1)$ or mutually cointegrated (Pesaran et al. 2001, p.290).

[4] With three regressors ($k=3$), the 5% and 10% critical value bounds are (3.23, 4.35) and (2.72, 3.77), respectively, which are obtained from Table CI in Pesaran et al. (2001).

[5] To investigate whether a deterministic trend is required, we also estimate equation (4) with a linear time trend. However, the findings are more conclusive when the F-test is applied to equation (4) without a linear trend.

[6] In the models of agricultural and non-agricultural trade with Canada, for example, the estimated orders of an ARDL(p, p_1, p_2, p_3) model in the four variables $(TB_{i,t}, Y_{US,t}, Y_{i,t}, ER_{i,t})$ are selected by a general-to-specific search, spanned by lag length $p = 0,1,2$ and $p_i = 0,1,2$, $i = 1,2,3$, using the AIC criterion (see Pesaran and Shin (1999) for details).

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Table 1. U.S. agricultural exports and imports with her major trading partners, 2004.

	Export		Import	
	Million $	%	Million $	%
Canada	9,669	15.8	10,286	19.1
Japan	8,148	13.3	482	0.9
Mexico	8,494	13.8	6,301	11.7
Sub-total	26,311	42.9	17,069	31.6
Total	61,383	100.0	53,977	100.0

Source: U.S. International Trade Commission.

Table 2. A partial summary of statistics for selecting the lag order and F-statistics of the existence of a level trade balance equation with Canada.

Trade Balance	Lag order	1 lag	2 lags	3 lags	4 lags	5 lags
Agricultural Trade Balance	AIC	-2.62	-2.61	-2.62	-2.56	-2.54
	$\chi^2_{SC}(1)$	0.15	1.47	0.02	2.77	11.47**
	$\chi^2_{SC}(3)$	1.83	2.33	2.48	9.41*	12.07**
	F -statistic	8.45	4.73	2.93	3.04	3.76
Non-Agricultural Trade Balance	AIC	-4.19	-4.16	-4.17	-4.66	-4.67
	$\chi^2_{SC}(1)$	2.42	0.01	19.93**	1.61	2.67
	$\chi^2_{SC}(3)$	3.91	0.54	21.85**	2.52	9.23*
	F -statistic	5.13	4.63	2.84	5.82	4.77

Note: **, and * denote significance at 5%, and 10% levels, respectively; AIC represents Akaike Information Criterion for a given lag length; $\chi^2_{SC}(1)$ and $\chi^2_{SC}(3)$ are LM statistics for testing no serial correlation against orders 1 and 3; The F -statistics for 10% and 5% critical value bounds are (2.72, 3.77) and (3.23, 4.35), respectively. The critical values are from Table CI in Pesaran et al. (2001).

Table 3. Estimated long-run coefficients of the bilateral trade balance model.

Country i	Trade balance	EX_i	Y_{US}	Y_i	constant
Japan	Agricultural Trade balance	2.78 (3.92)**	2.13 (12.50)**	-2.87 (-4.96)**	19.68 (1.97)*
	Non-Agricultural trade balance	1.56 (4.58)**	0.51 (6.19)**	-1.29 (-4.63)**	19.94 (4.13)**
Canada	Agricultural Trade balance	2.49 (2.86)**	-1.43 (-1.99)**	1.24 (1.77)*	5.24 (2.03)**
	Non-Agricultural trade balance	1.14 (6.04)**	-0.72 (-4.61)**	1.10 (7.25)**	-3.54 (-6.32)**
Mexico	Agricultural Trade balance	0.80 (1.64)*	-0.11 (0.93)	0.04 (0.10)	-0.81 (-0.05)
	Non-Agricultural trade balance	0.55 (5.61)**	1.10 (4.19)**	-0.12 (-1.61)	-17.15 (-5.42)**

Note: **, and * denote significance at 5% and 10% levels, respectively.

Table 4. Coefficient estimates of exchange rate and error-correction term based on autoregressive distributed lag model (ARDL).

		DEX	DEX_{t-1}	DEX_{t-2}	DEX_{t-3}	DEX_{t-4}	ec_{t-1}
Japan	Agricultural Trade Balance	-0.41 (-1.15)	-0.17 (-0.51)	-0.06 (-0.18)	0.01 (0.04)		-0.16* (-1.83)
	Non-Agricultural Trade Balance	-2.97** (-2.68)	-2.60** (-2.75)	-0.17 (-0.18)	1.73* (-1.65)		-0.38** (-2.53)
Canada	Agricultural Trade Balance	0.94 (0.44)	2.97 (1.22)	-0.79 (-0.34)			-0.58** (-3.61)
	Non-Agricultural Trade Balance	-1.56** (-2.57)	-1.70** (-2.42)	1.08* (1.69)			-0.53** (-2.97)
Mexico	Agricultural Trade balance	2.54** (2.72)	-0.79 (-0.84)	0.16 (0.16)			-0.14** (-4.40)
	Non-Agricultural Trade Balance	0.13 (0.68)	0.05 (0.33)	0.43** (2.54)	-0.06 (-0.34)	-0.42* (-1.96)	-0.46** (-3.74)

Note: **, and * denote significance at 5% and 10% levels, respectively.